National Renewable Energy Laboratory

Memo

To: Daryl Myers and Thomas Stoffel

From: Afshín M. Andreas

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Subject: Calibration of SRRL BMS and AOCS Quantum Sensors
Instruments: Licor LI-190 s/n Q8435 (BMS Global Horiz.), s/n Q20558 (BMS Upwelling), s/n Q8709 (AOCS Global Horiz.), and s/n Q8433 (AOCS Global Tilt).

NREL PV Radiometric Measurements Task monitored the millivolt and count output of four (4) SRRL LI-190 Quantum Sensors while measuring the spectral distribution of natural sunlight in global horizontal incidence mode on 31 August 2005 from 400 nm to 700 nm at 1nm intervals using a LICOR LI-1800 Spectroradiometer. The millivolt output from the BMS sensors were recorded by the BMS CR23X data logger and the count output from the AOCS sensors were recorded by the AOCS tattletale data logger.

The LI-1800 S/N PRS-158 spectrometer was calibrated against NREL's National Institute of Standards and Technology (NIST) Standard of spectral irradiance F571 on 14 April 2005.

The LICOR has an option to automatically download the data into Quantum (PAR) units of µmol/s/m^2/nm. The spectra were then integrated between 400 nm and 700 nm to produce the total power under each spectral distribution. All data were used to compute the calibration factors shown in Table 1.

Table 1. August 31, 2005 NREL Quantum LI-190 Calibration Summary

Time (MST)	Spectrum µmol/s/m^2	Q8435 mV (avg.)	µmol/s/m^2/mV CF	Q20558 mV (avg.)	µmol/s/m^2/mV CF
12:22	1769	-7.5614	-233.95	5.2258	338.52
12:23	1767	-7.5561	-233.85	5.2208	338.45
12:24	1764	-7.5420	-233.89	5.2146	338.28
12:25	1765	-7.5477	-233.85	5.2196	338.15
12:26	1765	-7.5464	-233.89	5.2199	338.13
12:27	1764	-7.5499	-233.65	5.2173	338.11
		Avg.	**-233.8**	**Avg.**	**338.3**
		Sigma	**0.1051**	**Sigma**	**0.1767**

Time (MST)	Spectrum µmol/s/m^2	Q8709 counts	µmol/s/m^2/count CF	Q8433 counts	µmol/s/m^2/count CF
12:22	1769	708.53	2.4967	477.40	3.7055
12:23	1767	703.28	2.5125	479.28	3.6868
12:24	1764	701.27	2.5154	475.25	3.7118
12:25	1765	705.30	2.5025	475.25	3.7139
12:26	1765	704.29	2.5061	478.27	3.6904
12:27	1764	706.11	2.4982	477.13	3.6971
		Avg.	**2.5052**	**Avg.**	**3.7009**
		Sigma	**0.0076**	**Sigma**	**0.0112**
	AOCS CF requires:	**Photons/s/ m^2/count**	**1.509E+18**		**2.229E+18**

Note: 1 micromole = 6.022e17 photons.

UNCERTAINTY

The estimated uncertainty in the LI-1800 spectral irradiance calibration is ±4.0% from 400 nm to 700nm. The accuracy of the CR23X data logger was about 0.8%. Estimated uncertainty in the derived calibration factor is ±4.8% (limit of error). Spectral data is plotted below.

Figure 1. Measured Spectral Distributions indicated by LI-1800 Spectroradiometer 31 August 2005